1st Satellite Navigation User Forum
25 February 1999

Minutes Package

Highlights
Detailed Minutes
Attendees List

Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

1st Satellite Navigation User Forum Highlights

Federal Aviation Administration (FAA) enlists users and other stakeholders in planning for transition to satellite navigation services.

Background

The Federal Aviation Administration (FAA) revealed its plan for developing a Business Case for transition to a totally satellite-based navigation (SatNav) infrastructure. At the direction of FAA senior management, an Investment Analysis Team (IAT) has been tasked to recommend a SatNav architecture and a funding profile for FAA-provided navigation services. The architecture and funding profile will be presented to FAA senior management in the form of a Satellite Navigation Business Case for approval in the summer of 1999.

Summary

The agenda for the SatNav User Forum began with a panel discussion of why the FAA needs to develop the SatNav Business Case. Panel members were Bob Wright (FAA/AFS-400), Norm Fujisaki (FAA/ASD-400), Alexis Stefani (Deputy Assistant IG for Aviation), and Jim Chadwick (MITRE CAASD representing Jack Fearnsides).

Following the panel discussion, Dr. Robert Rovinsky, IAT lead, presented a briefing on the Investment Analysis approach and plan. Dr. Rovinsky described that the Johns Hopkins Applied Physics Laboratory (APL) report on satellite navigation would be incorporated into the analysis and most likely influence decisions concerning SatNav back-up requirements. Dr. Rovinsky pointed out that the APL report noted some risks of relying on satellite navigation as sole means and cited several actions that would be necessary to mitigate those risks. The SatNav Business Case will have to consider the costs of risk mitigation.

Michael Harrison (ASD-100) followed with an update on navigation services as currently outlined in the FAA NAS Architecture. During the briefing, it was mentioned that one of the outcomes of the Investment Analysis may be a revision to the navigation and landing portions of the NAS Architecture. Mr. Harrison emphasized the need to quickly reach industry and user-wide consensus on the proper mix of safety and capability, transition, and how much backup is needed.

Mr. Kelly Markin (MITRE/CAASD) presented the final briefing in the morning session. Mr. Markin described alternatives and back-up capabilities that were currently being considered. He presented some preliminary performance data based on the Department of Defense maintaining 27 and 24 GPS satellite constellations and the impact of a "launch on anticipated failure" philosophy.

In the afternoon, attendees were provided an opportunity to respond and ask questions of the IAT user/industry panel. Robert Schwab of Boeing, Jack Ryan of the ATA, and Doug Helton of AOPA chaired the discussions. In their opening remarks, both Jack Ryan

and Doug Helton expressed the views of their constituencies and supported a transition to satellite navigation services as quickly as possible. Both speakers strongly endorsed the findings of the Johns Hopkins APL study. In addition, representatives from American Airlines, Continental, and UPS told the FAA that all new aircraft currently being delivered and accepted by their airlines are GPS equipped, with the capability to quickly upgrade to WAAS and LAAS when those services are available.

The FAA has made available the following information on its web site; www.faa.gov/asd/satnav/index.htm: A "Plain English" description of the alternatives currently considered; a copy of the January 1998 SatNav Investment Analysis Report; the current SatNav Investment Analysis Plan; an initial set of SatNav requirements; the Johns Hopkins GPS Risk Assessment Study; and an internal report on GPS backup strategies.

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Overview

The FAA described its approach to developing the investment analysis Business Case for transition to a satellite-based navigation infrastructure at the SatNav User Forum held on February 25, 1999. Over 140 airline, industry, and aviation organization representatives attended the forum. The FAA solicited comments to help shape key alternatives for the analysis and asked for a critique of current issues and assumptions that will drive the investment analysis. In addition, the FAA invited input on cost and benefit data, risk factors, technical requirements, and the pros/cons of their approach.

Morning Session

Welcome and Introduction

The agenda for the SatNav User Forum began with a welcome and introduction by Dr. Robert Rovinsky; lead for the SatNav Investment Analysis Team (IAT). Dr. Rovinsky presented the purpose for the User Forum, objectives, highlights, and follow-on meetings scheduled for February 26, 1999.

Investment Analysis Panel - Overview

The introduction was followed by the investment analysis panel overview discussion of why the FAA needs to develop the SatNav Business Case. Panel members included Bob Wright (FAA/AFS-400), Norm Fujisaki (FAA/ASD-400), Alexis Stefani (Deputy Assistant Inspector General for Aviation), and Jim Chadwick (MITRE Center for Advanced Aviation System Development (CAASD) representing Jack Fearnsides).

Bob Wright (FAA/AFS-400) – 1st Presenter

Mr. Wright spoke from the view of the WAAS/LAAS sponsor. The focus of his discussion centered on the following questions:

1. How do we absorb the Johns Hopkins Applied Physics Laboratory (APL) study now that it's been released (what are the operational implementation plans for integrating GPS into NAS)?
2. What are the safety costs/benefits (particularly, what is SatNav going to do for safety in public use airports per the Secretary's safer skies agenda)?

Norm Fujisaki (ASD-400) – 2nd Presenter

Mr. Fujisaki welcomed the attendees as the lead for Investment Analysis and Operations. He focused on the importance of viewing the investment analysis as an open process where the IAT actively engages the community to address known issues and resolve problems during the entire investment analysis process while moving towards the Joint Resources Council (JRC).

Alexis Stefani (Deputy Assistant Inspector General) – 3rd Presenter

Ms. Stefani stressed that two things are critical for Congressional acceptance: (a) the IAT must ensure that the information and recommendation passed to Congress for selecting an alternative be based on a clear and firm foundation (business case); and (b) user buy-in. Ms. Stefani shared the following comments:

1. It is important that the decision made by the investment analysis be based on input and data from the community.
2. The Hill wants to stay informed and prevent problems that have occurred in the past where last minute changes were made without an acceptable audit trail.
3. Congress requests user acceptance particularly with budget/funding issues for new programs. Also with the magnitude of variables, FAA must work with industry to reconcile these often-complicated issues.
4. FAA must analyze complicated internal issues such as supportability. It's crucial for the Administration, users, and Congress to have an effective and efficient investment analysis process with clear expectations with a solid foundation for the chosen alternative. This will ensure that the data and analysis for the investment analysis is done well.

Jim Chadwick (MITRE CAASD) – 4th Presenter

Mr. Chadwick representing Jack Fearnsides shared the following information:

1. The investment analysis must be under comprehensive review: user requirements, technical requirements, backup, architecture, funding, and costs. The basic question that must be answered is, "what do we need from SatNav and when do we need it?"
2. He cautioned to be weary of the trap of promising too much too soon. Thus, expectations must be in line with the budget, equipage, and must keep pace with the development of new procedures.
3. The interstate highway network can be used as a model for this investment analysis because it is an incremental benefit program. Incrementally, as financial investment increased the benefits realized increased (build some – some benefits).
4. A lot of hard questions still remain unanswered: sole means, jamming, interference, and backup. The response to these questions will determine the alternative chosen.
5. To continue funding SatNav, Congress wants a clear and compelling statement of the costs and benefits as the program evolves, coupled with a system that traces program changes.
6. The key to the investment analysis will be to keep expectations in line with reality and present a clear picture of costs and benefits for the chosen alternative.

Dr. Robert Rovinsky (ASD-410) - Investment Analysis Plan and Approach

Following the panel discussion, Dr. Robert Rovinsky, IAT lead, presented a briefing on the Investment Analysis Plan and Approach. Dr. Rovinsky outlined the background, scope, schedule, preliminary ground rules and assumptions for the SatNav investment analysis (cost and benefit), issues, and the activities that the IAT will conduct in examining various strategies for possibly transitioning from the current ground-based navigation and landing system to a satellite-based system.

Dr. Rovinsky explained that the Johns Hopkins APL report on satellite navigation would be incorporated into the analysis and most likely influence decisions concerning SatNav back-up requirements. Dr. Rovinsky pointed out that the APL report noted some risks of relying on satellite navigation as sole means and cited several actions that would be necessary to mitigate those risks. The SatNav Business Case will have to consider the costs of risk mitigation.

Michael Harrison (ASD-100) - Architecture Perspective

Michael Harrison (ASD-100) followed with an update on navigation services as currently outlined in the FAA NAS Architecture.

1. During the briefing, it was mentioned that one of the outcomes of the Investment Analysis might be a revision to the navigation and landing portions of the NAS Architecture. He raised several questions during his presentation; "Which do we leave in place, the NAVAIDS or the landing aids, or both?" He presented a scenario for reducing ground-based NAVAIDS by 1/2 to 2/3. "There is no question that we are going to SatNav but what do we leave on the ground for backup?" "What is the plan and time frame for sustaining NAVAIDS?" Mr. Harrison emphasized the need to quickly reach industry and user-wide consensus on the proper mix of safety and capability, transition, and the level of backup needed.
2. Two issues were raised with the APL report: (1) intentional interference; and (2) unintentional interference.
3. 2nd civil frequency should be included as a transition issue.
4. A decommissioning plan and criteria must be in place before a decommissioning schedule can be developed, announced, and decommissioning begins.
5. He proposed an operations concept that included the current network, phase down plan to an interim network, and a phase down plan to a final network that will depend on consensus for a backup strategy.
6. He asked the question, "Does GPS require a backup?" His response, "The answer to this question will depend on focusing on resolving the intentional/unintentional interference issue and on identifying how much should be spent on backup." "Determining backup has two extremes, a fully redundant system and a reserve system." He referred to determining backup capability as an insurance policy not a terrorist prevention policy that should be viewed in terms of the threat. The SOIT is currently looking at threat analyses.
7. In closing, the key to successfully determining the cost of the SatNav program will be gaining consensus on three issues: (1) transition (what will be transitioned and alternatives/strategies); (2) proper mix of safety and capacity capabilities; and (3) how much backup is needed.

Kelly Markin(MITRE/CAASD) - Alternatives Analysis

Mr. Kelly Markin (MITRE/CAASD) presented the final briefing for the morning session. He presented the key guidelines used to develop the alternatives and described the four alternatives and backup capabilities currently being evaluated to meet future NAS navigation requirements.

Current WAAS, and two reduced capability WAAS architectures, along with their complementary ground-based navigation aid combinations, are being compared with keeping the current VOR/DME and ILS system in place. In each of the four alternatives, current LAAS is an additional precision landing option.

- Alternative 1 provides no wide area augmentation for GPS; VORs and DMEs are maintained. Precision approach will be evaluated considering ILS and/or LAAS.
- Alternative 2 provides wide area augmentation to GPS for en route through nonprecision approach. Many of the VORs and DMEs network will be maintained. Precision approach will be evaluated as in Alternative 1.
- Alternative 3 adds a vertical guidance capability to WAAS to support precision approaches up to Cat I, allowing possible reductions in ILSs. Precision approach will be evaluated considering ILS and/or WAAS/LAAS.
- Alternative 4 provides a robust implementation of WAAS and LAAS.

Alternatives 2 through 4 will consider several variations of backup capability, including VOR/DME, ILS, Loran-C, as well as interference resistant GPS avionics/antennas. Preliminary performance estimates were presented for each of the alternatives.

The four alternatives were described in terms of three areas; government-provided functionality, operational capability, and user equipage. Mr. Markin also presented preliminary performance data based on the Department of Defense maintaining 27 and 24 GPS satellite constellations and the impact of a "launch on anticipated failure" philosophy.

Mr. Markin stressed that the four alternatives presented were not fixed but should be viewed as a snapshot of main or core alternatives and welcomed input on the process, inclusions, and areas requiring sensitivity from the user/industry community.

Afternoon Session

User/Industry Panel Discussion

The afternoon session began with a panel discussion made up of leader representatives of the aviation user/industry community. Robert Schwab of Boeing chaired these sessions, assisted by Jack Ryan of the Air Transport Association (ATA) and Doug Helton of the Aircraft Owners and Pilots Association (AOPA). In their opening remarks, both Jack Ryan and Doug Helton expressed the views of their constituencies and supported a transition to satellite navigation services as quickly as possible. Both speakers strongly endorsed the findings of the Johns Hopkins APL study. In addition, during the question and answer discussions, representatives from American Airlines, Continental, and UPS told the FAA that all new aircraft currently being delivered and accepted by their airlines are GPS equipped, with the capability to upgrade to WAAS and LAAS when those services are available.

Bob Schwab (Boeing) – 1st Presenter

Mr. Schwab shared the following comments and concerns on SatNav:

1. Stressed several importance issues for developing the investment analysis:
   - Developing a strong business case.
   - Focusing on enhancements.
   - Baselineing is an important issue to consider because with so many different systems and understanding of benefits it can be difficult.
2. Raised two questions, "How should the technology for the business case be quantified?" and "How should the investment analysis be framed?"
3. Noted his experience working through the C/AFT process to help frame the process and shared assumptions to help various business cases.

Jack Ryan (ATA) – 2nd Presenter

Mr. Ryan shared the following comments and concerns on SatNav representing ATA:

1. Goal – achieve sole means with satellite navigation.
2. FAA must move quickly to implement WAAS/LAAS. The FAA should be sensitive to delays in the WAAS program (delays have a major impact on the avionics industry).
3. FAA must move quickly to employ two additional GEOs to achieve sole means capability, oceanic through Cat I. This should not be delayed given the findings of the Johns Hopkins APL study.
4. Air carriers must be more involved with developing reports and studies (investment analysis report, alternatives study, GPS transition plan).
5. FAA must move swiftly to conclude these reports with air carrier endorsement.
6. Air carriers must participate in the JRC because they are large investors in the program.
7. SatNav is not like the Highway Improvement Project (air carriers have already invested $$$ in GPS equipment and could invest $100M more).
8. Air carrier NAVAID insurance plan will not include Loran-C.
9. Recommend that DME be chosen as the backup for air carriers.
10. US government must recognize that GPS is a national resource and should act decisively to protect the spectrum.
11. FAA must collaborate directly with the user community to formulate a national GPS plan.
12. Recommend direct user representation and participation in IGEB activities.

Doug Helton (AOPA) – 3rd Presenter

Mr. Helton shared the following comments and concerns on SatNav representing AOPA:

1. The following GPS/WAAS Benefits should be considered in the benefits study:
   - Operational/Economic GPS/WAAS Benefits.
     - Greater all-weather airport access. This is viewed as one of the largest benefits.
     - Direct point-in-space navigation.
     - Signal coverage & performance.
     - Economic gain by communities served by improved airport access.

- Safety GPS/WAAS Benefits.
  - Improved situational awareness (e.g., provided by moving map display).
  - Vertical guidance on approaches.
  - Area navigation safety features.
  - Foundation for other safety functions (e.g. terrain avoidance, ADS-B, flight information services).

  Mr. Helton also stated that vertical guidance on a gradual descent profile is not always wanted. Sometimes, if ceilings are low, a "dive and drive" approach below clouds in low altitude level flight provides a longer time to see the airport environment and make a decision.

  An RNAV display is a foundation for the display of graphic weather information.

- Benefit/Cost.
  - Multiple user segments, cost sharing (aviation is a minority user of satellite navigation and should not have to bear all costs). This was viewed as a major flaw in the previous study because it was not included.
  - Can replace entire suite of avionics (VOR/DME/ADF/ILS).
  - Greater capability on the ground for fewer dollars than existing NAVAIDS.

2. Sole-means SatNav and Johns Hopkins APL GPS Risk Assessment Study.
   AOPA concurs with the APL study, but noted that the study has received a lot of bad press.
   - The larger question is, "How do we now implement the findings of the study (how do we get from here)". The following concerns were addressed:
     - The study answers the technical question – Yes.
     - WAAS and RAIM modules conservative.
     - Should not wait for 2nd frequency.
     - Institutionalization will require user experience with the system. The big question is, "Are users ready for sole-means?"
   - GA experience with GPS is positive (1/3 members ready for sole-means now).
   - GA is likely to accept sole-means if:
     - positive experience.
     - affordable avionics and database.
     - operational benefits.
     - adequate transition period. If benefits are offered up front it would take 10 years to transition (for buy-in).

3. Recommendations:
   - Move forward with WAAS/LAAS.
   - Deploy 2 additional GEOS.
   - Implement procedures and operational approval (approval of flight operations using satellite navigation).

- Certify system/avionics as sole-means of aircraft navigation as soon as possible
- Involve users in funding decisions so the aviation community doesn't pick up the tab for everything.
- Users should be involved in defining transition requirements (need greater involvement from the civil side).
- Airline community should be involved in the transition plan for backup (they have to reach consensus on what the requirements are and how much they can afford).
- The aviation community should decide what the recommended solution is for SatNav, not the IAT. The IAT should provide the information to the aviation community so that the recommendation can be made.

Summary of Industry Panel Question and Answer Discussion:
Following the afternoon session, attendees were provided an opportunity to ask questions and provide feedback to the IAT user/industry panel. The following questions, comments, and responses were discussed (The planned breakout session format was not implemented because of overwhelming support for continued group discussion).

Comment Attendee. Stated that Mr. Helton's presentation was the clearest position that he has heard. He also wants assurance that the investment analysis will include an apples to apples comparison when analyzing and comparing alternatives and when considering performance measures.

Question Dee Ann Divis (GPS World Magazine). Stated that given that the aviation user community has never been involved in the IGEB, why do you now want representation?

Response Mr. Ryan (ATA). The IGEB has to decide how they will allow participants from the aviation community to be involved in the process, but having direct input is our requirement.

Question Bruce Nordwall (Aviation Week). Noted that two groups were not represented at the User Forum, (1) air traffic controllers and (2) DoD

Response Dr. Rovinsky. AOPA is an indirect link to air traffic controllers because they are tied into what they are doing. Also, we have representatives from the DoD community on the IAT, the Joint Precision Approach and landing System (JPALS) and we have receive a lot of input from equipment manufacturers. However, we do need to solicit direct involvement and input from the air traffic controller community.

Comment Ron Swanda (GAMA). Stated that the investment analysis has the attention of the manufacturer community. He shared the following comments.

1. GAMA concurs with the GPS study. Manufacturers have invested a large amount of money in WAAS and LAAS equipment development.
2. Disappointed that it appears that the investment analysis is going backward. If the FAA does not go forward with WAAS and LAAS development, they would have to find a way to recover those costs. If we change the direction now radically there will be no means of recovering

the costs from equipment they have already invested in. Manufacturers would rather invest future R&D funds in WAAS and LAAS equipment, not improvements in equipment that uses GPS alone.

3. It's important for the IAT to determine an optimal system to recommend and not just follow what DoD dictates.
4. Must consider the additional cost of Loran-C.
5. For users seeking precision approach minima, the increased number of precision approaches including the cost/benefit of lighting systems on the ground must be included in the analysis.

Question Attendee. Wanted to know if DoD needs were being addressed and if a solution was being considered for what was best for civil and military aviation users.

Comment Honeywell Representative. Reported that the DoD (JPALS) group did an analysis of alternative precision approach architectures. Local area DGPS stood out as a solution. A report is due out Friday (26 February) recommending a military version of LAAS.

Comment Ron Lee (Air Force Space Command). Reported that DoD's most recent draft of the GPS Operational Requirements Document (ORD) will be going to Hank Skalski at DOT and others Monday (March 1). All are invited to comment on it.

Question Dee Ann Divis (GPS World). Questioned funding availability for all GPS users.

Response Attendee. The money should be taken out of the trust fund because the aviation community has paid enough for the non-aviation community who also benefits.

Response Doug Helton (AOPA). In reference to benefits for the non-aviation community he cited agriculture as one example. He noted that agriculture users may also benefit from the U.S. Coast Guard system that uses non-directional beacons to broadcast local differential GPS corrections. The question then arises, why was the Coast Guard system developed when its users' needs could be met by WAAS. The answer is that the Coast Guard system could be developed quickly and inexpensively.

Response Dr. Rovinsky. While there are a lot of non-aviation benefits, the problem is trying to quantify the benefit. In addition, the political issues are a problem. Dr. Rovinsky solicited data and input from attendees and stressed that it is hard to build a case without real data.

Response Doug Helton (AOPA). The augmented system should be declared a national resource because of the magnitude of GPS users (rail/trucking/agriculture). Thus additional funding resources should be evaluated.

Response Attendees. There was a lot of discussion about the newly developed National GPS Differential System (NGDPS) which raises concerns for a push towards creating a national policy for GPS.

Comment Jack Ryan (ATA). Noted that harmonics of TV channels 23 and 66 are very near L1 and should therefore be the ones that cause interference to GPS if any problem exists. Jack noted that the Johns Hopkins report authors took some GPS receivers and flew them very close to transmitting antennas of TV channels 23 and 66 and saw no effect. However, they did not include this fact in their report because it is only anecdotal evidence and does not prove that all GPS receivers can tolerate high signal levels from cable channels. Jack asked them to include it in their report and state that it is only anecdotal evidence, but they did not do that.

Comment Col. Jim Armor, USAF, Head of DoD GPS. Offered to answer questions on the military's position for GPS.

Question Attendee. Will the civil community be allowed to put up additional GPS satellites if that's the best solution?

Response Col. Armor (USAF). This is more of a civil community question because they want a more robust system. Col. Armor noted that GPS has an open system architecture and civil-only satellites are unlikely to need the expensive military hardening that DoD requires. The GPS Joint Program Office has even offered to the European community that they could contribute satellites with compatible signals in a combined constellation. Since the offer was extended to the Europeans, Col. Armor was certain that it could be offered to the FAA.

Question Ron Swanda (GAMA). Will GPS jamming exercises stop at some point?

Response Col. Armor (USAF). Jamming tests are an ongoing part of the navigation warfare program that's coordinated with the FAA where operation forces are trained to operate in a jamming environment using small jammers with various scenarios within FAA authorization and limitations.

Question Doug Helton (AOPA). What is the timeline for jamming exercises, when will we see decreased activity?

Response Col. Armor (USAF). Testing will not end, they are ongoing, conducted in a secure environment, under FAA approval. The data from the test is classified.

Question Doug Helton (AOPA). What current technology does the DoD have for jam resistance and interrupting signals?

Response Col. Arbor (USAF). The commercial community appears to be ahead in developing anti-jamming technology.

Question Dave Scull (Optimus Corporation). Will the DoD be involved with spoofing?

Response Col. Armor (USAF). The DoD is concerned about this technology but can't confirm or deny.

Response Mike Harrison (FAA). Recognize that there will be an ongoing level of effort for jamming. However, operational tests are performed in fixed areas during fixed times. A hot area notice is issued for all tests.

Question Russ Chew (American Airlines). Asked if the investment analysis would contain a sensitivity analysis to possible delays caused by a lack of funding. Russ noted that if a project being implemented by American Airlines is behind

schedule, sometimes it is more cost-effective to put more money into the program so that it will be done more quickly. He noted that the balancing of the national budget could have a negative effect on return on investment (ROI). (He also noted that the FAA's problems with the Appropriations Committee should not affect their customers, e.g., American.)

Response Dr. Rovinsky. In theory, within the Acquisition Management System, when a program receives JRC approval there is a contract between the FAA and the public for funding and a schedule commitment. However, in reality there are budget cuts that without budget reform may cause funding tradeoffs. So sometimes funds are moved and the contract is violated. We hope to have a better tracking system so we can better analyze the changes. What's missing is that (1) we are making internal decisions without information from the user community and (2) a better understanding of how the decisions impact the user community. The goal then is to develop a common database with FAA and user community information so that sensitivity/impact analyses can be performed to aid decision making so that decisions are not made in a vacuum.

Comment Mike Harrision (FAA). Would like to see sunk costs for development programs captured better in investment analyses.

Question Nick Stoer (Nick Stoer and Associates). What are ATA's and AOPA's transition and backup systems, and equipage assumptions for precision approach and navigation?

Response Doug Helton (AOPA). AOPA doesn't have an annual transition plan but will have to look at this. He stated that ¾ of the fleet over 10 years will equip with Loran-C and 9% in the first year. Transition doesn't start until the last system is in place in 2 to 10 years. In deciding to go to sole-means we will have to look at economic and performance issues. Their decision will also be based on what the air carriers decide to do.

Response Jack Ryan (ATA). Air carriers have to participate in the investment analysis. 20% of 4k to 5k air carriers will equip with GPS by year 2005. This is a guess given the lack of success for moving WAAS to the 2000 milestone (not credible). This is also important to air manufacturers who build WAAS. It depends on the success of the program. They are hesitant because WAAS is not on schedule.

Response Jack Ryan (ATA). Hopes that the investment analysis will show all the benefits the users will buy into (if they have input); then they will be more credible and industry will buy in, but not if this decision is determined in a vacuum.

Response Russ Chew (American Airlines). Every new aircraft ordered by American will have space to put a multi-mode receiver. American is ordering 260 Super 80s for delivery by 2002. All of them are required by contract to have GPS upgradeable to WAAS. He noted that an accident involving an American Airlines aircraft would have been avoided if precision approach guidance had been available at a particular nonprecision approach runway. He noted that for the most part, accidents are due to some kind of aberration and involve controlled flight into terrain (CFIT). He noted that half of American's aircraft

already have GPS upgradeable to WAAS. American Airlines financial analysis showed that the reduced cost of maintenance of new equipment more than offsets its capital cost. This is particularly true with ADF because of the higher failure rate of older equipment, there is value to removing ADFs off the airplane. GPS retrofit is now an option because of all the value added.

Comment Larry Barnett (FAA). Stated that the 2000 budget was discussed at the NATCA symposium. In FY96-99 Congress approved 99.8% of the President's request for the FAA budget.

Response Jack Ryan (ATA). Responded that the budget request had already been cut from what the FAA had indicated that it needed.

Question Attendee. In one of the alternatives Kelly Markin (MITRE/CAASD) briefed, why were ADFs maintained when they could have been deleted?

Response Kelly Markin (MITRE/CAASD). They were not deleted because they have low cost to FAA and would likely be used by many users.

A break was held.

Dr. Robert Rovinsky reopened the sessions with a review of the reference materials in the back of the User Forum notebook. He solicited comments and input for the NAS decision criteria and benefits prospectus. He noted that for the last investment analysis there was concern that the benefits were overstated and noted that for this investment analysis a better job must be done at capturing these benefits; however, data is needed to better describe and quantity the benefits.

Question Attendee. Asked other operators to describe their equipage and plans.

Response Bob Hill (UPS). 1/3 of the UPS fleet will equip with GPS. The entire fleet will be equipped with GPS by the end of 2001. They expect to upgrade to WAAS in January or February of 2000. He also noted that there was a dramatic increase in the number of cigarette lighters being installed in general aviation aircraft. They do not belong to smokers; they belong to pilots who are using GPS handheld devices that can draw power from cigarette lighters.

Response Sam Shrick (Continental Airlines). Continental and Continental Express will not take delivery of any new aircraft without GPS. He expects all aircraft to have GPS by 2002.

Comment Carl Dean (BAH). The community needs to be concerned about operator (air traffic controller and pilot) risk because the purpose for the new technology is to improve capacity. The backup system should provide similar capabilities to the operational (Main) system (meaning that it should be a RNAV system). If not, then when the system fails, the operators will not be able to protect against significant losses in capacity in the event of a widespread outage.

Question Dee Ann Divis (Geo Info Systems). Asked if the European system would be compatible with WAAS.

Response Kelly Markin (MITRE/CAASD). Responded that the current scope of the investment analysis activity is on the U.S., but that efforts are underway to ensure that the systems are interoperable.

Response JP Fernow (MITRE/CAASD). Reported that ICAO GNSSP is developing standards to ensure interoperability and that the FAA, Europe, and Japan Civil Aviation Bureau meet periodically to discuss interoperability. [As noted below, Steve Bellingham of NAV Canada later reported that there is a strong collective will to have a single worldwide standard.]

Question Attendee. Will changes to the GPS constellation, such as 30 satellites be considered in the investment analysis activity.

Response Kelly Markin (MITRE/CAASD). No changes were being assumed in the constellation; however, past studies have been conducted to determine the effects of both larger constellations and shorter restoration times in the event of satellite failures. He noted that shortening the satellite replacement time has a larger effect on improving availability than a larger constellation with current assumptions on satellite replacement. He said that some sensitivity results will be included in the report, and that they could support the case for a national policy to have a larger GPS constellation.

Response Col. Armor (USAF). Cited a Presidential Decision Directive (PDD) to maintain 24 satellites.

Question Col. Armor (USAF) asked if MITRE/CAASD had looked at (in addition to larger constellations and changes in restoration policy) the effect of including an integrity channel on GPS satellites (which could effectively provide a WAAS navigation broadcast message).

Response Kelly Markin (MITRE/CAASD). Noted that MITRE/CAASD looked at that in past studies but it does not apply to the current investment analysis. The time period of interest for the current study is through approximately the year 2015. In order for the integrity channel to provide significant benefits, it would have to exist on the majority of satellites. Because of the long satellite lifetime, it could not be available on most satellites until near the end of the study period.

Question Col. Armor (USAF). Asked if MITRE/CAASD had looked at 30 and 36-satellite constellations.

Response Kelly Markin (MITRE/CAASD). Replied that MITRE/CAASD had done an analysis of availability of both 30- and 36- satellite constellations.

Comment Col. Armor (USAF). Noted that GPS satellites without the military hardening would be less expensive and suggested a cost tradeoff.

Question Jim Nagle (BAH). Asked, what time frame were GEO satellites assumed to be available in the investment analysis.

Response Kelly Markin (MITRE/CAASD). Replied, that an assumption had not yet been made on the year of GEO availability, but that it would be assumed that GEOs would be launched as soon as feasible.

Comment Mr. Nagle (BAH). Cautioned, when computing costs, that costs other than just building, launching, and flying satellites should be considered. When working for INMARSAT, Mr. Nagle got an agreement from INMARSAT that only building, launching, and flying satellites need to be considered, and not satellite design. The inclusion of additional costs could change results.

Comment Mr. Nagle (BAH). Also suggested that if approached properly, INMARSAT might allow FAA to use the most recently launched and fifth INMARSAT 3 satellite. It is currently at 25°E. It is currently in non-revenue service. A location of 99°W would be suitable for FAA needs. Kelly Markin expressed appreciation for the input.

Question Dave Scull (Optimus Corporation), former president of the Institute of Navigation (ION). Cited the European desire to have a system under civil control and mentioned the discussions between the Germans and Russians of using GLONASS satellites as part of the European GNSS. He asked if this possibility would be considered in the investment analysis activity. A robust European economy might support GLONASS.

Response Kelly Markin (MITRE/CAASD). Noted, it was not being considered.

Response Col. Armor (USAF). Reiterated his statement that the US suggested that Europe build additional satellites broadcasting a signal with the GPS signal structure, and added that the US could live with them broadcasting additional signals at GLONASS frequencies.

Question Dr. Robert Rovinsky. Asked, what effect this would have on the investment analysis activity?

Response Col. Armor (USAF). Noted that it could increase the number of useable satellites and therefore should be considered in the investment analysis.

Question Dr. Robert Rovinsky. Asked, if this is something that has a reasonable chance of happening and, if so, by when. If there is a significant probability that the system will be implemented and it will be implemented during the period of the study for the investment analysis, then it should be considered, but if not, then it is outside the scope of this study and will not be included.

Response Col. Armor (USAF). The system might be implemented by 2010.

Question Jim Treacy (FAA National Resource Specialist for Aircraft Certification). Asked Doug Helton (AOPA) and Jack Ryan (ATA) what they would consider to be acceptable backup systems and wondered specifically if a backup system needed to be an RNAV system.

Response Jack Ryan (ATA). Responded that he and Doug Helton (AOPA) would plan to get together with the airlines and formulate their own backup plan and present it to the FAA. But for now RNAV is a good plan. He also said that 70% of air carriers have FMSs (which can provide RNAV guidance from a variety of sources that are not thought of as RNAV systems, as long as there are a minimum number of sensors with reasonable geometry).

Response Doug Helton (AOPA). Respond, that although a system that would have seamless transition from GPS would be desirable, cost is also a factor. He does not have clear input from AOPA members. Therefore a consensus may not exist among AOPA members. He will have to seek input from AOPA members over the next couple of months to get clear direction to validate a backup plan possibly through a survey. If not, then Mr. Helton and Mr Ryan would have to make a decision for their constituents. They will get together in the next few weeks.

Comment Bob Hill (UPS). Three-quarters of the UPS fleet have inertial systems with DME updating (which would provide RNAV capability). One-quarter of the fleet does not have this capability. UPS does not have plans to install inertial systems on the unequipped quarter of the UPS fleet. However, they could revisit their decision based on the outcome of FAA and user studies.

Question David Underwood (Airspace Global). Noted that FAA appears to be proceeding with ADS-B, which requires RNAV inputs. He understands that there are plans to reduce the number of radars.

Response Dave Olsen (ASD-140). Responded that the current assumption is that independent surveillance systems will continue to exist, at least in high-density airspace, throughout the study period.

Question Jim Treacy (FAA). Asked what the DoD position is on GPS satellite restoration policy, given that availability is highly sensitive to the restoration policy (e.g., launch on anticipated failure).

Response Col. Armor (USAF). Stated that he cannot show a policy in writing, but reiterated that the DoD would try to have 24 satellites on orbit at all times. Therefore, if the number drops below 28, another launch will be scheduled. (By maintaining 28, they hope to ensure 24.) He does not know how to get a written DoD assurance on that. He suggested that within the interagency group the FAA should request an anticipated failure policy.

Response JP Fernow (MITRE/CAASD). He attended a meeting with personnel from the Second Space Operations Squadron (2SOPS) at Schriever AFB in January 1999, and that they reported that 7 GPS satellites are expected to be launched in the next year and a half.

Question Jim Treacy (FAA). Asked ATA and AOPA, what is their recommended alternative for backup and how many GA users have the old-fashioned VOR/DME-based RNAV system?

Response Doug Helton (AOPA). Responded that he does not have actual data but estimates the number is low, perhaps 25,000 to 30,000 (These users may want VOR/DME for a backup. Another roughly one-third of GA users may prefer Loran for a backup, and another third of GA users may prefer GPS for a backup.) Approximately 80,000 Loran receivers are installed, but most of these are VFR units. [Check these numbers) it may be 25k to 30 k have VOR RNAV base, 80k have Loran, and 65k have GPS]

Response Dr. Robert Rovinsky. Noted that when ASD-410 did last year's WAAS cost/benefit study, it was assumed that there would be full (100%) equipment by following classes of users by the following dates based on users and equipment manufacturers (he does not know if these numbers still apply):

User Segment	WAAS	LAAS
Air Carriers	2007	2008
Air Taxis	2006	2008
GA	2007	One third by 2009
Business Jets	2006	

Question Jim Treacy (FAA). Asked Jack Ryan, which alternatives would be reasonable for air carriers. Which alternatives may be suitable depends on whether their fleets already are equipped with inertial systems.

Response Jack Ryan (ATA). Responded, that he would do a survey and find out, and try to have results in a week or two.

Response Bob Jackson (Raytheon). Responded, from discussions he has had with regional carriers, they are aggressively equipping.

Response Jim Treacy (FAA). Responded, that not that many regional carriers have inertial systems.

Question Dee Ann Divis (Geo Info Systems). Stated that she had heard that the Europeans want to export a new global standard for satellite navigation and mandate its usage worldwide. This could increase prices worldwide. (Editor's note: This may be a reference to the GNSS-2 program, also called Galileo, reported recently in the press.) Is there data to support a sensitivity analysis of the issues and the cost/benefits?

Response GAMA Representative. Responded that manufacturers are working hard to have a single worldwide standard, any system outside of the standard will have a difficult time finding a manufacturer.

Response Doug Helton (AOPA). Reported that AOPA has over 33 international affiliates, some of whom are in Europe. He reported that the European program confuses the members of these AOPA affiliates. He believes that the Europeans seem to assume that their satellite navigation programs will increase trade. However, putting up another system that provides the same services already provided by GPS does not seem logical and seems counter productive for compatibility and consistency with the system we have. The Europeans appear to be split regarding whether their future navigation architecture should be Eurofix or EGNOS.

Comment Terry Pearsall (Strategic Technology Institute). Volunteered that the Aircraft Electronics Association would provide a representative to help Doug Helton perform his studies.

Response Doug Helton (AOPA). Accepted the help.

Comment Dan Streeter (AFS-410). Volunteered providing data for the equipage team.

Comment Carl Dean (BAH). Suggested contacting Steve Zaidman and Joan Bauerman who has data for the European GPS.

Comment Russ Chew (American Airlines). American Airlines participated in an IATA study of future navigation architectures for Europe. He said that users in Europe don't even want to pay for EGNOS, let alone a successor system. Users are not opposed to EGNOS or GNSS; however, they are against the way it is funded. He believes Europe has zero chance of funding a competitor system if it is funded the same way.

Response Doug Helton (AOPA). It was his understanding that the future European system would be paid for by States and that there would be no user fee. The future system would not provide an integrity message. The private sector in Europe does not want States to be involved in augmentations. The private sector would provide different GNSS augmentation services. Doug said that this ought to send a message to the U.S. government that if we are not careful, there will be many standards and aircraft will not have enough room in the cockpit to put equipment that complies with all the standards.

Response Steve Bellingham (Nav Canada). The decision to fund Galileo would be made later this year. Implementation would be over a 10-year period. It is also his understanding that it would be publicly funded. The motivation is that Europe wishes to participate in economic spin-offs. Europeans are talking to Russians directly regarding the possibility of using GLONASS frequencies or techniques. From the perspective of standards, there is a collective will on both sides of the Atlantic to come up with a common standard.

Response Dr. Robert Rovinsky. Asked how this subject affected the investment analysis.

Question Jim Treacy (FAA). Asked Doug Helton what a reasonable strategy for GA would be for a backup. FAA was planning to, but has not yet performed, a simulation study of how well air traffic controllers would be able to handle a widespread navigation outage, during which many pilots could ask ATC for radar vectors. If air carriers and a percentage of the GA users have a backup, then those pilots would not be asking ATC for vectors. In IMC, he asked what the mix of equipage is. He said that ordinarily (not restricted to IMC), the ratio of GA aircraft in the air to air carrier aircraft is 3:1. Also, Jim asked for those without a backup, how often could they tolerate an outage?

Response Doug Helton (AOPA). The real question is how often are there interrupts. If it is frequently then everyone will want a backup system. How much risk are they willing to take or how much mitigation are they willing to pay for is the next question. If outages are frequent and over a large area, then clearly a backup is needed. He said that a good survey of members is needed. He also reported that AOPA has periodic community town meetings. He said that the feedback from those meetings is that one-third of AOPA members think that

GPS is good enough as a sole means now. Two-thirds seem to want a backup. Half of those wanted LORAN-C and half want VOR. Mr. Helton said that members were not given information on how much a backup would cost. He stated that maintenance costs of the current VOR/DME network result in an 80 cent per gallon fuel tax. LORAN maintenance costs result in a 7 cent per gallon fuel tax.

Response Jack Ryan (ATA). In a high-density traffic environment, most GA aircraft are high-end users. In general, business jets are equipped as well as air carrier jets.

Question Nick Stoer (Nicholas Stoer & Associates). He was surprised at the cost of maintaining and replacing NAVAIDs. He understands that these cost figures are out of date and that newer systems may cost less and may cost one-quarter as much to maintain as older systems. How will we build this into the investment analysis?

Response Dr. Robert Rovinsky. The FAA is looking into getting more recent estimates.

Response Mitch Narrins. (FAA). TheFAA is procuring 13 ILSs so that it is difficult to see why the data from those procurements could be inaccurate. Also, FAA has recently bought some newer generation DMEs, so the data being used are not as old as alleged.

Question John Foggia (ANSP). Will the airspace benefits for reduced separation effects on delay be considered in the benefits? He reported on a study done by the NY Port Authority on local differential GPS at Chicago O'Hare. The benefits go beyond changing out equipment and include reductions in separation. The benefits over a 5-year period in the Port Authority alone were billions of dollars. The study involved someone from the FAA (John Boek?) at Atlantic City, the airlines, and the Port Authority. The first step was to use FMS-based RNP RNAV. The second phase included GPS.

Response Dr. Robert Rovinsky. We have airspace experts (airspace modelers) looking at this. We would be very interested in getting a copy of the NY airspace study data to review for this study.

Comment Lori Hill (Allied Signal). Recounted a large number of types of transponders that had to be designed and certified because of FAA requirements, including Mode C, Mode S, ADS-B, and TIS. She noted that this imposes a large cost burden on manufacturers that they must pass on to aircraft operators. She advocated setting one requirement (one technical standard) rather than a multiplicity of requirements, each with its own box and certification. She would also like to see the FAA make a full solution, not half. She would rather go to the final decision sooner than to invest in a solution that will only ultimately move toward the final goal, WAAS/LAAS.

Response Dr. Robert Rovinsky. Acknowledged that FAA is hearing that there is a lot of impact on the manufacturer and user community of program delays and changes in program direction.

Comment Lori Hill (Allied Signal). Also noted that Allied Signal had developed the KLN 88, which has a LORAN-C capability. She said that she is not a

proponent of LORAN-C because she questions the systems safety (flight tests did not show that it was a good system and units have the tendency to lose the signal in bad weather conditions when it is really needed). She advocated more study and making sure that the H-field antenna, or any other proposed solution, really works before adopting it.

Response Dr. Robert Rovinsky. Noted that the focus of the investment analysis (due in June) is not on establishing the technical feasibility of the various proposed backups. Those issues will need to be addressed later. The investment analysis activity can only identify risks at this point.

Comment Daryl McCall (Rockwell Collins). The biggest hurdle to implementing GPS augmentations is a lack of a proper GPS fault hazard assessment and advocated that FAA fund one whose results could be made available to the public. (Concerned about the conservative estimate for GPS and integrity because we didn't know what to expect, but as proper fault hazard assessment for Cat II and III proceed, the estimate can now be more accurate.)

Response Dr. Robert Rovinsky. Asked Mr. McCall to send notes to the IAT to help them understand the issue.

Question Dee Ann Divis (Geo Info Systems). How will ground based cost data be validated.

Response Dr. Robert Rovinsky. Replied that FAA estimates based on previous purchases will be subjected to a sanity check, and that FAA has records of sustainment costs.

Question Dee Ann asked if sales data were used.

Response Bob Rovinsky replied that in certain cases, sales data are available, but not for new equipment. He said that FAA will ask manufacturers what the basis for their estimates is and look at their data.

Question George Chang (retired FAA). Noted that when choosing an alternative that that safety should be the focus. He asked if the alternative architectures are safe and of the four alternatives which is expected to have the highest safety assessment?

Response Kelly Markin (MITRE/CAASD). Noted that safety is a driver in all architectures and will be included in the investment analysis

Response Dr. Robert Rovinsky. Noted that safety assessment will be used in the investment analysis in two ways: (1) as a discriminator that prevents or allows a given architecture to be considered at all, and (2) each program office is required to perform a safety assessment of its own program.

Question Russ Chew (American Airlines). Noted that before American Airlines replaced Omega equipment, they considered not doing it. However, they put together a data collection program using ACARS that recorded when a short-cut was granted by ATC, which only RNAV-equipped aircraft would have been able to use. (This did not include the National Route Program.) The cost savings from the short cuts alone justified the replacement with an RNAV system.

Response Dr. Robert Rovinsky. Noted that the FAA is confident in the estimates of costs, and that the estimation of benefits is going to be a more difficult task for this investment analysis. The benefits analysis will require better understanding and quantification (when will the benefits materialize, how will they materialize, and how will they be guaranteed). This is important because benefits will drive the air carrier industry.

Closing Comments

Dr. Robert Rovinsky closed the meeting by expressing appreciation for Jack Ryan and Doug Helton's briefings and participation. He asked that comments be sent to him at <Robert.Rovinsky@faa.gov>. The next public meeting with users is scheduled for March 30, probably in the morning with breakout meetings in the afternoon on costs and benefits. And he thanked everyone for attending.

1st SatNav User Forum
25 February 1999

SatNav Investment Analysis Team

Name	***Organization***
Core Members IAT	
1. ***Robert Rovinsky***	***ASD-410***
2. Hank Cabler	AFS-430
3. Bruce DeCleene	AIR-130
4. Bob Fandrich	ARN-100
5. Mike Harrison	ASD-100
6. Carl McCullough	AND-730
Supporting Members IAT	
1. Robert Bonanni	AAS-100
2. Millie Butler-Harris	ASD-400
3. Maria DiPasquantinio	AND-730
4. Leo Eldredge	AND-730
5. Dan Hanlon	AND-730
6. Greg Joyner	AAR-300
7. Diana Liang	ASD-430
8. Dave Olsen	ASD-100
9. Dave Peterson	AND-730
10. Ray Swider	AND-730
FFRDC Members IAT	
1. ***Mel Zeltser***	MITRE/CAASD
2. James (JP) Fernow	MITRE/CAASD
3. Kara MacWilliams	MITRE/CAASD
4. Markin, Kelly	MITRE/CAASD

Name	***Organization***
Contractor Support Members IAT	
1. ***George Huxhold***	***SETA/ASD-410***
2. Bob Anoll	SETA/ASD-100
3. Phil Baker	AIR-130 Contractor
4. Mark Fuhrmann	AMTI/AND-730
5. Ron Hinkel	SETA/ASD-100
6. Mark Kipperman	SETA/ASD-410
7. Don Markel	ECARS/ARR-100
8. Skip Mead	AMTI/AND-730
9. Don Mixon	ECARS/ARR-100
10. Sharon Pringle	SETA/ASD-410
11. David Schall	SETA/ASD-100
12. Gary Solom	TAC/AND-730
13. Chris Webb	AMTI/WAAS TAC
14. Anne Yablonski	SETA/ASD-410
15. David Yancey	SETA/ASD-140

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Speaker/Panel Member Attendees List

Name	***Organization***
1. Jim Chadwick	MITRE (CAASD)
2. Norm Fujisaki	FAA, ASD-400
3. Mike Harrison	FAA, ASD-100 (Acting)
4. Doug Helton	AOPA
5. Kelly Markin	MITRE (CAASD)
6. Bob Rovinsky	FAA, ASD-410
7. Jack Ryan	ATA
8. Bob Schwab	Boeing
9. Alexis Stefani	OIG
10. Robert Wright	FAA, AFS-400

1st Satellite Navigation User Forum
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Attendees List

Name	***Organization***
1. Nasir Ali	Hughes Space Comm.
2. Gi-In An	Rockwell Collins
3. Jim Armor	USAF
4. Herb Bachner	FAA, AST-100
5. Jim Banks	ATCA
6. Larry Barnett	AB Management Associates
7. John Beukers	Int'l Loran Associates
8. Steve Bellingham	NAV Canada
9. Mark Boguski	Airsystems ATM, Inc.
10. John Bonyan	Lockheed Martin
11. Larry Bessette	FAA
12. Joseph Brown	AFFSA/XRC Car Inc.
13. Jim Calhoun	Booz Allen & Hamilton
14. Kevin Carlson	Chicago Aviation
15. George Chang	Retired
16. Russ Chew	American Airlines
17. Vince Chirasello	Atlantic Coast Airlines--Regional Airline Assn.
18. Gary Church	Aviation Management Associates
19. Howard Cleveland	FAA, ANI-780
20. Dave Correia	FAA

Name	*Organization*
21. Ronald Davis	Booz Allen & Hamilton
22. Carl Dean	BAI
23. Jim Dill	ITT Aerospace/Comm.
24. Dee Ann Divis	Geo Info Systems (GPS World)
25. Karen Dove	SETA, AND-740
26. Beverly Dulaney	GAO
27. Harry Eberlin	Crown Communications
28. Susan Eicher	FAA
29. Leonard Epstein	Draper Laboratory
30. David Evans	Air Safety Week
31. Dan Fisher	ANPC
32. Eric Ford	Canadian Marconi
33. John Foggia	Chicago Aviation
34. R. Gastin	FAA, AFS-410
35. Dave Goehler	Jeppesen
36. Maurice Granby	FAA, ANI-80
37. Stan Grubaugh	FAA, AFS-400
38. Tim Hartman	Lockheed Martin
39. Trevor R. Henry	FAA, ARN-200
40. Capt. Bob Hilb	UPS
41. Lori Hill	Allied Signal
42. Ray Hilton	ATA
43. Doug Hodgkins	Joe Del Balzo & Associates
44. Daryl Horn	Horn Engineering
45. Dennis Hughes	SAIC
46. Bob Jackson	Raytheon

Name	*Organization*
47. Steve James	British Embassy
48. Erik Johannessen	Megapulse
49. Cody Johnson	AMTI
50. Denis Kelleher	Honeywell
51. Capt. Kerry King	HQ AMC/XPRN
52. John Knuti	FAA, AND-340
53. Julian Kryzanowsky	Scitor Corporation
54. Ron Lee	Space Comm.
55. Robert Lilley	Illgen Simulation
56. Tracie Lockhart	SETA/AND-740
57. Phil McCabe	Lockheed Martin
58. Daryl McCall	Rockwell Collins
59. Richard McFarland	Ohio University
60. Sean McCort	Atlantic Coast Airlines/Regional Airline Assn.
61. Jane Mellors	European Space Agency
62. Jeff Meyers	FAA, AIR-130
63. James Miller	United Airlines
64. Paul Miller	Lockheed Martin
65. Robert Mongeau	Lockheed Martin
66. Marion Moon	Raytheon
67. Arun Murthi	Aviation Safety Engineer
68. Jim Nagle	Booz Allen & Hamilton
69. Mike Nash	Lockheed Martin
70. Pat Nolte	AF/XORF-GA
71. John Noto	GAO

Name	*Organization*
72. Bruce Nordwall	Aviation Week
73. Colleen O'Hara	Federal Computer Week
74. Patrice Pasturel	United Parcel
75. Terry Pearsall	Systems Software
76. Bill H. Phaneuf	ALPA
77. Marty Pozesky	Pozesky Aviation Consultant
78. Melissa Pyron	OIG/JA-10
79. James Rankin	Ohio University Avionics Engineering Center
80. Pat Reines	Honeywell
81. Jamie Roberts	Airport Systems Int'l Inc.
82. Rudy Ruana	Jeppesen
83.Joseph Santos	Chicago Aviation
84. Robert Schumann	Honeywell
85. Randall Schwartz	RADIX
86. Don Schwanz	Honeywell Airport Systems
87. David Scull	Optimus Corporation
88. Bill Sears	ATA
89. Chris Shank	USAF
90. Sam Shrick	Continental Airlines
91. Gary Skillicorn	FAA, AND-740
92. Robert Smith	Delta Air Lines
93. Doug Spandau	ANS-700/NISC
94. Dave Spunnach	Crown Comm.
95. Kip Spurio	DOD/PBFA (Mitre)
96. Nick Stoer	Self
97. Victor Strachan	Litton Aero Product

Name	*Organization*
98. Victor Strachan	Litton Aero Product
99. Don Streeter	FAA, AFS-400
100. Yanelle Strong-Fischer	FAA, ANS-700
101. Ron Swanda	GAMA
102. Marvin Swenson	Hughes Space Comm.
103. Stormy Thornhill	Crown Comm.
104. James Tracy	FAA, ANM-103N
105. Sharon Trodden	OIG/JA-10
106. Dave Turner	Aerospace Ind.
107. Bob Tyler	FAA, ARX-100
108. David Underwood	Airspace Global
109. Brad Unnesch	United Airlines
110. Rich Walton	COMSAT
111. Paul Wagoner	FAA, AND-730
112. Maury Wilber	MCA Resource Corporation
113. Steve Wolf	FAA, AND-740
114. Nick Woll	Seneca
115. Wilfred G. Volkstadt	DCS Corporation
116. Alan Yost	Volpe Center